

Digital Predistortion for RF Communications: From Equations to Implementation

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Abstract

This article covers the mathematical fundamentals of digital predistortion (DPD) and how it is implemented in a transmitter's microprocessor and hardware. It addresses why DPD is needed in modern communication systems and explores how the mathematical model captures real-world signal distortion.

Introduction

DPD is an acronym that will be familiar to many RF [radio frequency] engineers, signal processing enthusiasts, and embedded software developers. DPD is ubiquitous in our cellular communications systems, enabling power amplifiers (PAs) to efficiently deliver maximum power to an antenna. As 5G drives up the antenna count in base stations and our spectrum becomes ever more congested, DPD has emerged as a key technology to allow for the development of efficient, cost-effective, and specification compliant cellular systems.

Many of us have a unique understanding of DPD based on our own perspectives, be that from the purely mathematical viewpoint or the more constrained implementation on a microprocessor. Perhaps you're an engineer evaluating the performance of DPD in your RF base station product or an algorithm developer who is curious as to how mathematical modeling techniques are implemented in real-world systems. This article aims to broaden your knowledge and empower you to fully grasp the topic from all angles.

What Is DPD and Why Is It Used?

When an RF signal is outputted from a base station radio (see Figure 1), it needs to be amplified before it is transmitted through the antenna. An RF PA is used to do this. In an ideal world, the PA takes an input signal and outputs a higher power signal that is proportional to its input. It also does this in the most power efficient way possible so that most of the DC power supply provided to the amplifier is converted into signal output power.

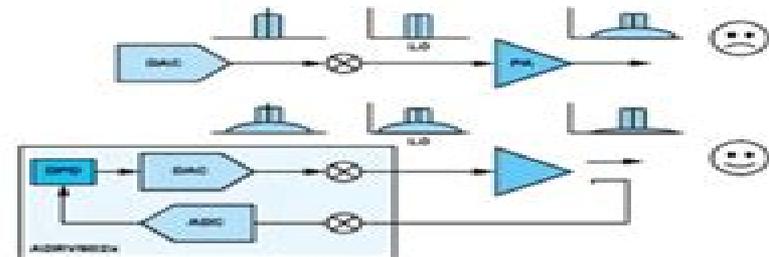


Figure 1. Block diagram of a simplified radio structure with and without DPD.

However, this isn't an ideal world. PAs are made from transistors, which are active devices and inherently nonlinear. Now if we use PAs in their "linear" region (linear here is a relative term, hence, the quotation marks) as shown in Figure 2, then the output power is relatively proportional to the input power. The downside of this approach is that the PA is generally used in a very inefficient state with most of the power provided being lost as heat. We often want to use PAs at the point where they are beginning to compress. That means if the input signal is increased by a set amount (say 3 dB), the PA output does not increase by the same amount (maybe only by 1 dB). Obviously, the signal is being significantly distorted at this point by the amplifier.



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